



Performance benchmarks for SciGlass ECal

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State of common benchmarks framework

ePIC had inherited benchmarks from Athena:

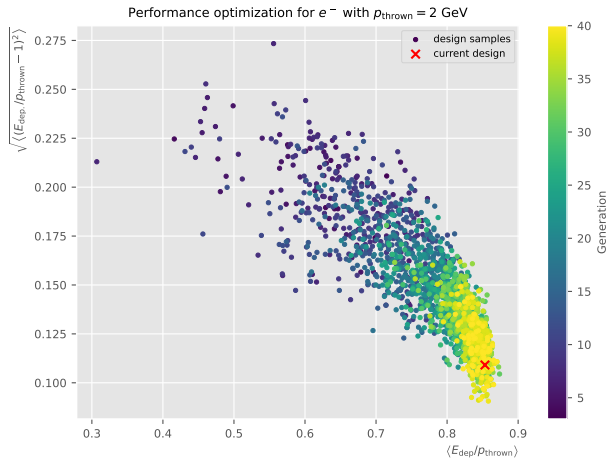
- » https://eicweb.phy.anl.gov/EIC/benchmarks/detector_benchmarks
- » https://eicweb.phy.anl.gov/EIC/benchmarks/physics_benchmarks
- » https://eicweb.phy.anl.gov/EIC/benchmarks/reconstruction_benchmarks

Something to learn from!

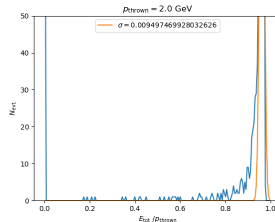
- » Running on the grid after each software change (Continuous Integration)
- » Transparent procedures – source code available
- » Unfortunately, analysis and interface are unsophisticated
- » Not friendly to deadline-driven development - no user adoption

A use case: detector optimization

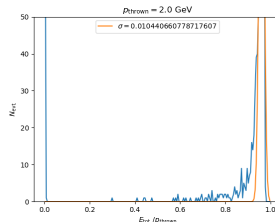
Example toy optimization for 2 objectives:



current design:

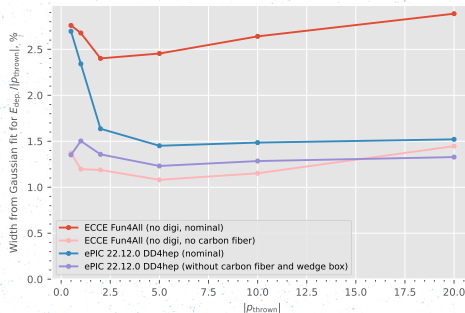


a design with "optimal" resolution:



Real improvement depends on having rigorous and robust benchmarks

Energy resolutions from a Fun4All reproduced in DD4hep



- » Disabled SiPM statistics and removed 1 mm carbon fiber around towers in Fun4All
- » Removed a 0.25 mm thin carbon fiber wrap and wedge walls in DD4hep
- » Consistent gaussian peak widths for electrons

π rejection for SciGlass in ECCE calorimeter

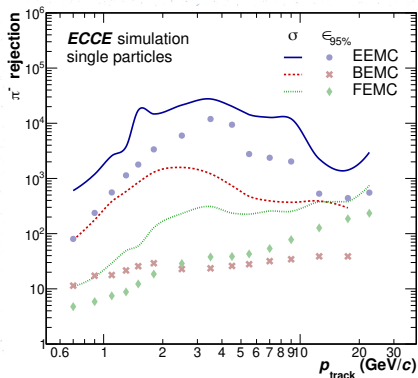


Figure 20: Pion rejection factor for the different ECals with $E/p > 1 - 1.6 \sigma_e/E$ or based on a $\epsilon_e \approx 95\%$ cut.

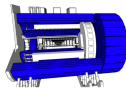
arXiv:2207.09437v1

Friday, June 17th, 2022

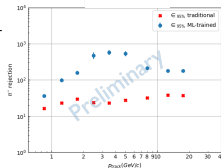
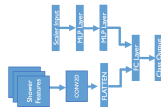
Machine Learning: Hall A/C Joint Meeting - William Phelps 34

BECAL PID Study

A. Quiroga, W. Phelps, C. Fanelli, and J. Huang



- Higher pion rejection compared to conventional methods when considering high electron efficiency ($\sim 95\%$)
- Work is in progress (started on thanksgiving)
- Interface with ECCE software: reco-track, track projection, 7x7 calorimeter towers near track (track-based clustering by AI) [\[Link to details\]](#)
- Many models tried: MLPs, CNNs, Multi-Input models, Autoencoders, GANs.
- Ongoing hyperparameter tuning on 14 GPU nodes

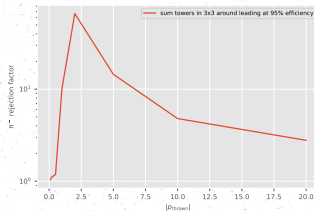
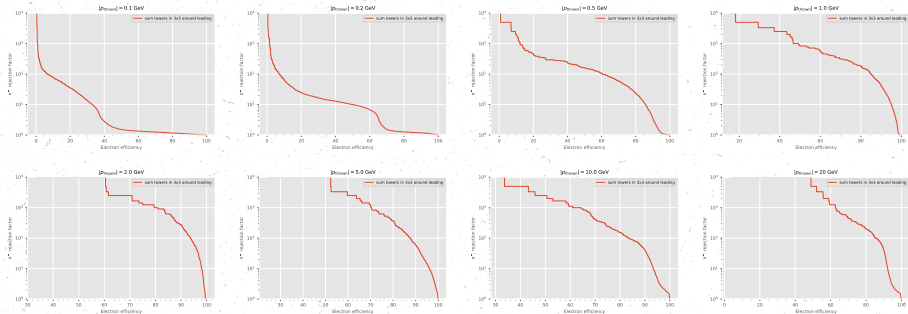


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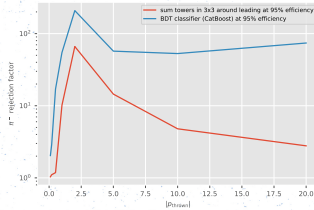
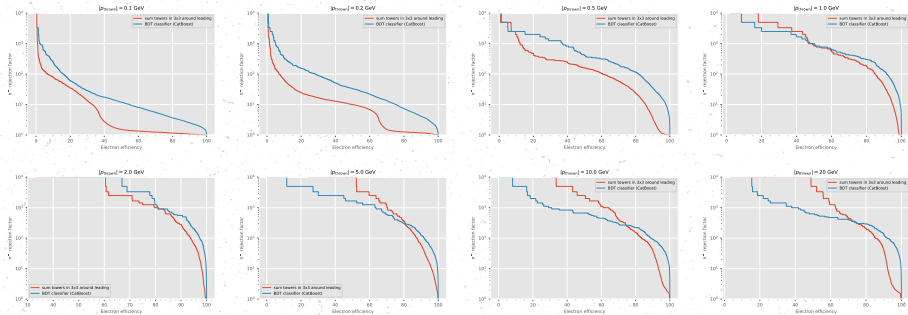
https://indico.jlab.org/event/546/contributions/9980/attachments/7933/11151/machine_learning_hall_ac_2022_phelps.pdf
(was shown at 2nd EIC AI/ML Workshop)

Rejection at $\epsilon = 95\%$ is given in red points

State of the pion rejection study





State of the pion rejection study



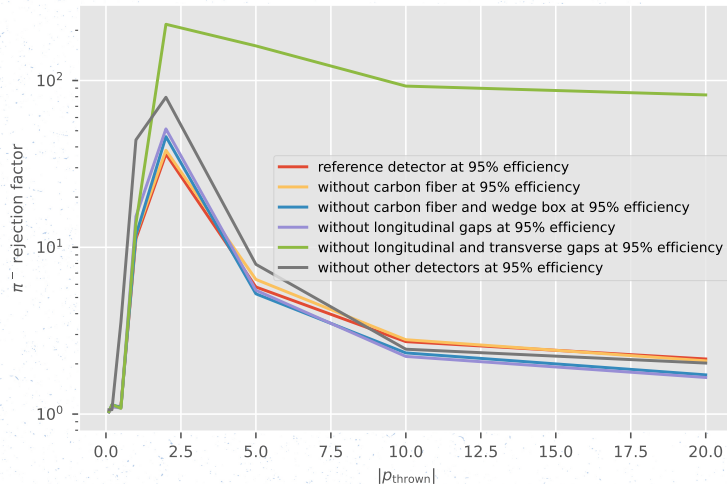
Future steps

- » Implement clustering for Sci-Glass
- » Implement remaining benchmarks according to the charge
- » Study Geant4 material simulation: X_0 , λ_{int}
- » Implement realistic readout in EICrecon
 - Optical statistics (contribution to the $1/E$ term)
- » Porting Imaging/Sciglass analyses to the benchmarks infrastructure?

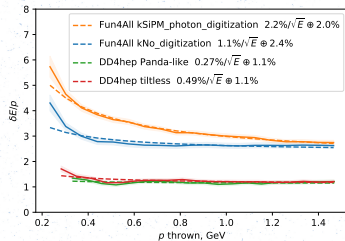
Backup

- 
- 
- » Switch from ePIC geometry version from 22.11.1 to 22.12.0
 - » Enabled Birks effect correction (relevant for π rejection)

Pion rejection: breakdown



Resolution from the simulations



https://indico.bnl.gov/event/17074/contributions/68207/attachments/43231/72716/dd4hep_fun4all_cmp.pdf

ECCE proposal

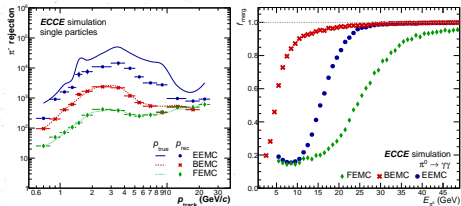


Figure 2.20: (left) Pion rejection factor for the different ECals with $E/p > 1 - 1.6\sigma_E/E$ and shower shape cuts applied as a function of true and reconstructed momentum. (right) Fraction of neutral pions for which the showers from their decay photons are merged into a single cluster and can not be reconstructed using an invariant-mass-based approach for the different electromagnetic calorimeters.

<https://doi.org/10.5281/zenodo.6537588>

For a Gaussian peak $(1 + \text{erf}(1.6/\sqrt{2}))/2 = 94.5\%$ efficiency - **that's not how they've defined, it's more like $(1 + \text{erf}(0.6/\sqrt{2}))/2 = 72.5\%$**

https:

[//indico.bnl.gov/event/17706/contributions/70849/attachments/44499/75685/](https://indico.bnl.gov/event/17706/contributions/70849/attachments/44499/75685/)

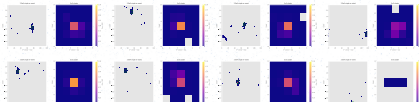
SHA256E-s5115227--974190a22dcbaa41b8860f33dc2db97d7f6d5980359db3a641c6b13994f6e4

pdf

Single particle event and clustering

No proper clustering for SciGlass in ElCrecon or Juggler – adjacency using decoded cellID is not implemented yet (see discussion on Mattermost). A crude clustering was implemented by selecting an $N \times N$ region around the leading tower.

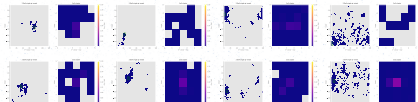
Example e^- events and corresponding 5×5 clusters



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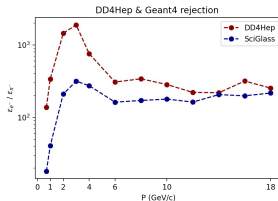
Example π^- events and corresponding 5×5 clusters



https://indico.bnl.gov/event/17844/contributions/71396/attachments/44966/75855/pi_rejection.pdf

A beam-test simulation wasn't reproduced in DD4hep

Geant4 vs DD4Hep SciGlass



<https://indico.bnl.gov/event/17710/>

- » Simulation for 21x21 grid array
- » A private Geant4 framework that is also used for beam-test simulation
- » DD4hep simulation setup with EcalNegative geometry for SciGlass
- » Here, a slightly different definition of the rejection factor is used: $(\text{TPR})/(\text{FPR})$ (instead of $1/(\text{FPR})$)